The Universities and Technological Education.[1]

By PROF. W. W. WATTS, F.R.S.

TECHNOLOGICAL education may be defined as the development of those sides of learning which will enable us to extract the highest possible good from the resources of the world, and in the process to make life at least endurable and, if possible, pleasant to the maximum number of people; to avoid waste and extravagance in both production and use; to keep and leave the world beautiful and peaceful; and to do all this with such a margin of economy as to deplete as little as possible our children's heritage in the earth of which we are but tenants for life.

In the use of every kind of resource, animal, vegetable, or mineral, man has been woefully extravagant, partly through thoughtlessness, but mainly through ignorance. To take their share in improving this state of things is a task not unworthy of the greatest and most ancient universities, as well as of those of newer growth, and of those other institutions which, because of their heart-whole and deliberate devotion to this end, are not yet deemed worthy to be reckoned as universities.

Among the functions of these universities and institutions should be the training of men who are to lead the industries forward in the direction of higher efficiency, smoother and more salutary working, and increased production; men who shall know sufficient of the laws of Nature to extract through their operation all the energy and material to which we are entitled, and who never forget that Time the Avenger, tardy but sure, will exact from them the penalty for any thoughtlessness or neglect.

The Student.

It is fair to demand that the technological student should come from school with a really good general education and the culture which such an education should give. He should have such a knowledge of languages that he can not only use those he knows, but will also be able without great difficulty to acquire any other which may prove essential to him; such an acquaintance with literature that he really understands how to read and extract from the printed word what it is able to give him; facility in writing clearly and intelligently; so much knowledge of geography and history as will enable him to get hold of any information he may require; and a thorough grounding in mathematics and elementary science.

In the study of the group of sciences and arts germane to the professional training, the best that can be done is to pick out in each subject those matters which are common to a number of technological subjects, to teach them to mixed classes of convenient size, and to supplement them where necessary by special additional instruction or direction. The amount of common matter is much greater than is generally supposed, and such courses, if thoughtfully designed, will go a great part of the way. Here the strength of broad-based institutions is manifest, for in them it is possible, without undue expense, to make use of all existing departments. There must necessarily be either incompleteness or waste of effort and overlapping in the case of institutions devoted to a single branch of technology; and such institutions should never be founded unless it has been proved impossible for bodies of university rank to undertake the work.

Curricula.

It is as well to insist that technology must be based on a thorough knowledge, practical and theoretical, of the relevant sciences treated as pure sciences. In the past most industries have advanced by means of a cumbrous and exclusive course of trial and error. It is only in the more recent developments that advantage has been taken of the principles and general laws worked out by the scientific man in his laboratory, the royal roads in both the pursuit and the applications of science. In future the technologist must be a scientific man, not only in his knowledge, but also in his attitude and outlook. In his life-work he will not be really successful if he is satisfied with things that are. He is to be the introducer of new things in a *régime* which may fallaciously appear to have reached finality. This he can be only if his knowledge is wide and so ingrained in him that he can make full and practical use of it.

In every science the great aim should be to bring out the principles and the general laws which have been established, the lines of thought and experiment on which they rest, the means by which they can be and have been tested, and the consequences which flow from them. The teaching scheme is thus made easier as well as more efficient, for such principles are common ground, equally necessary to each branch of technological instruction. It is in the illustration of them that the teacher must bring out their contact with the technical practice of industry.

While holding fast to the principles of science, it is essential that the scheme at this stage should be exceedingly elastic and capable of rapid variation to meet the advance of industrial applications. What is at once the hardest task and the severest test of the successful teacher is not how much he can teach, but how much he dare leave out. In any case, he must be firm in meeting the question which few of us escape: "What use is this to me?" He can see farther than his students, farther even, perhaps, than his technical advisers, and he should be able to show that such apparent superfluities are like the hidden strands in concrete, without which the material would fail under some of the stresses it is designed to meet. It is his duty to remember that, whatever may be a student's intentions as to his future, he cannot be sure of controlling that future.

The guidance of technical advisory committees is of inestimable advantage, not only in the later year or years when purely scientific work is merging into the technical applications of it, but also to some extent while pure science is being studied. In both cases, however, their function should remain advisory and never become mandatory. The last word must rest either with the director or principal teacher, or with the faculty of which he is a member.

In the later year or years of the course the instruction will naturally become more highly specialised, and if the previous scientific training has been thorough and sound and the student has learnt how to make practical use of his knowledge, progress will usually be rapid.

It is essential, too, that at this stage, but preferably earlier as well, the student should be trained in writing of what he has learnt, or in summarising the results obtained by his own practical work, in clear and concise and, if possible, non-technical language which can be easily understood by the type of man under whom his professional work will be carried on. By this he will be able to display most clearly how much of his work he has really grasped and how far he sees into its consequences, while he will, at the same time, be acquiring a gift of great service to him in his career.

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[1] From a paper read before the Congress of the Universities of the Empire at Oxford on July 6.

Touch with Industry.

It is a vital question at what stage contact with industry should be initiated. Until a student knows some of the features of the industry in which he will be engaged, he finds it difficult to realise the significance of many parts of his training. On the other hand, if he goes into the shops, the works, or the mine too soon, he is not possessed of enough knowledge to profit fully by his experience. The advantage of early touch outweighs its disadvantages, and contact should begin early, and be renewed at several stages of the course. The student may at first gain little actual knowledge in the mine or workshop, but in working there for a period by the side of the men whom he will afterwards direct he will gain a most valuable knowledge of their customs and limitations, their predilections and weaknesses; and he will be laying down a foundation of experience which will usefully guide him when he comes to the difficult task of handling men himself. At the same time, while watching the technical skill of the expert workman, he will acquire respect for accuracy and delicacy of workmanship and for that astonishing proficiency which prolonged practice alone can give. What is of scarcely less importance is that at this stage he will hear a whole gamut of technical nomenclature which has before been mere jargon to him, if he has met with it at all. No one is more intolerant of the phraseology of the expert than the "practical man," but no one is more tenacious of his own terminology. It is well that the student should learn the latter while he is still in the position of the under-dog, so that it may not trip him up later. As his course proceeds it is natural that workshop and field experience will become of greater educative value. He will be entrusted with higher work and so gain new experience.

Directors and Teachers.

One of the greatest difficulties in the future, as it has been in the past, will be the staffing of technological departments. Such departments must be directed by the right kind of men—men not only of good intention, but also of wide industrial knowledge, capable of dealing with students and of organising their staffs; men of ideas and energy, devoted to their own research and that of others; and, above all, men of achieved success. There seem to be but three ways of securing such men: (1) To pick the right man whenever and wherever found, pay him his price, and leave him to teach as and what he thinks best and to select his *personnel* and material, as well as his methods and lines of research; (2) to take from the industrial side men who have made their mark and a competence, but, from interest in their subject and love of the work, are willing to continue in harness in what is one of the pleasantest, if not the least exacting, of professions; or (3) to select competent and trustworthy men who have found touch with industry from the academic side, and to allow them to supplement their pay by private professional work conducted under proper restrictions. Under present conditions the universities will have to fill their posts from the last two classes.

Subordinate staffs have also to be considered. Here again the pay is generally inadequate to secure the services for long periods of the most desirable men, and it is arguable that it is well this should be so. There are many inducements to attract men to the staffs of applied science departments: the continuation of their technological education and the possibility of obtaining higher degrees, the developing of their teaching ability, the opportunity of increasing their proficiency in research and improving their status and reputation thereby, the earning of additional pay by carrying out industrial work of research character or otherwise, and the introduction to, and contact with, industrial men who will eventually have research work to dispose of or employment to offer. It is essential, however, that means should be provided to retain some, and those not the least promising, for longer periods in order to give stability to the department and to the head of it the responsible support which he is entitled to look for.

It will also be to the advantage of every department that it should be sufficiently strong to allow one or other of its members to take an occasional period of time for the purpose of study, research, or even business work. This would react not only on the value of the teaching, but also in spreading the reputation and increasing the efficiency of the department by maintaining closer touch between it and the business world. If well managed, it need not involve heavy additional cost. It is chiefly a question of organisation and of a liberal outlook.

Research.

It is essential that research should form part of the curriculum of every technological student. Whatever his future career, in addition to routine work, it is certain that he will come across new conditions and new difficulties, something for which he may have met no precedent—problems, in other words, which need to be investigated on scientific lines before they can be solved. It is not essential that the research should be other than of a purely scientific nature. What is essential is that he should get to realise that the easiest and quickest way may often be to obtain facts and inferences at first hand, that he should learn how to question Nature, and acquire confidence that, if he can put his questions skilfully, he will usually obtain, after Nature's way, an answer which will contain, though it may conceal, the solution to his problem.

It is still more necessary that the teachers should engage in research, and naturally this in most cases would have some more or less direct bearing on industrial problems. Apart from the fact that only a man engaged in the production of new knowledge can be a really first-class teacher, in no other way can he establish contact with the highest development of the industry in which he is interested and thus secure the confidence and respect of those engaged in it. An active research school is the best symptom of a live and active technological, as it is of a scientific, department; it tends to attract the right kind of student, trains the best kind of staff, and is a legitimate way of keeping the department before the eyes of business men.

If it is possible to pass the best students on to the staff for a short period before they take up outside appointments, and to afford them reasonable leisure to embark upon research, the school will be much strengthened and the worth of the students considerably enhanced. A certain amount of teaching work is by no means a drawback, for it will enable them to consolidate their knowledge and render it more accessible when wanted. A larger staff than otherwise may be thus maintained, and the department will be more stabilised in the event of having to face the possible loss of one or more of its senior members.

Another consequence of a strong research school will be to attract from outside those engaged in industry who have special problems of their own to solve which cannot be so well dealt with in the laboratories to which they have access in works or elsewhere. This should, of course, receive encouragement. The introduction of outsiders of the right kind to the laboratories is of service in several ways. It "spreads the light" by keeping industrials informed as to the progress of science and the improvements of methods of investigation, and as to the precise nature, cost, and limitations of scientific inquiry. It impresses upon them the necessity for experimental accuracy, and shows how closely the sciences are now interwoven, and how results obtained in one science or branch may be imported to assist progress in another. Better relations are established between the institution and the industries surrounding it, mutual confidence is engendered, and personal acquaintance is encouraged to the advantage, on one hand, of the industries, and, on the other, of the students who may find eventual employment therein.

A corollary is that in certain cases research by staff or students may be in part carried on in works laboratories outside the university, and the considerations just set out apply as well to this case. Care is requisite that industrial research should not degenerate into anything of the nature of routine or testing work. This should be excluded, and the universities should not in any way compete with firms which specialise in this direction. Only where this class of work involves problems which are new or exceptionally difficult, or need the employment, or even formulation, of new principles, should it be undertaken by university departments.

The Product.

The type of man which it should be the aim of the universities to turn out should possess those qualities which distinguish the best type of scientific man—not merely knowledge of his subject and technical ability to use that knowledge, but capability to introduce the scientific method into his conduct of everyday life and into his dealings with his colleagues and subordinates. He must be willing to study *all* the conditions of his problems before he is sufficiently satisfied with their solution to carry them into effect. These conditions require, not *a* solution, but *the* solution which can be brought into operation with the least possible disturbance of the things that are, without needless change of raw material, machinery, or *personnel*, but with the advantage of diminished cost, enlarged production, and increased value or efficiency.

If this is the aim, the product will be the best type of technologist. He will not necessarily be the type of man suited to occupy immediately the highest position in his business. But the work given him to perform will be so well done that it will be impossible for his character, competence, and ability long to escape the watchful attention of his chiefs. It will not be long before he is chosen for more and more responsible work until he attains high rank in his profession. I do not believe it is possible that men of managerial type, captains of industry, will ever be technically trained as such. The universities should endeavour to produce such a type of man that his superiors will take him by force, and almost against his will, from his technological work to direct the bigger issues.

Conclusions.

(1) As much as in any other walk of life, the education of the business man must be a liberal one. His mind must be as agile, and he must be as well provided with intellectual weapons, as any other well-educated man.

(2) A course of technological education thoughtfully laid out is, as an instrument for mind-training and in the nature of the product turned out, in no way inferior to the higher branches of language, literature, history, or philosophy. The work is as hard, the problems to be solved as difficult, the reasoning as acute, the intellectual joy in success as great; while its urgency to the nation and to mankind is one of the most pressing matters that educationists have to face.

(3) In the multiplicity and complexity of subjects there is no longer time for the most liberal of educations to be as broad as heretofore. Some universities are even specialising in a single dead language as an honours subject, holding, perhaps rightly, that a thorough knowledge of one is better than what can be attained, in the time available, of two. Technological education has anticipated this specialisation only by a few years.

(4) There is no less worthiness and dignity in the newer education than in the old. All higher education is, and always has been, technological. The learning of the older universities has been used, and has even been moulded for the purpose, to equip the parson, the poet, and the politician; and both the peer and the proletarian can gain from the study of classical literature some facts or theories to guide them in their respective vocations.

(5) The business man has good right to demand that institutions of university rank shall supply his demands as well as they have dealt with education for the professions. The polytechnic system has not had the success that was expected in educating his foremen and workmen. He must not be again disappointed when he seeks higher education for himself. He expects, and has a right to expect, that the type of education he needs shall be, not a by-play or a by-product, but a worthy aim in itself; and if the universities will not give it to him, he will take his own steps in the matter.

The Exploitation of Irish Peat.[1]

By PROF. HUGH RYAN.

THERE are about 6,000,000 tons of turf used every year in Ireland, but this quantity is almost insignificant in comparison with the total amount, about 4,000,000,000 tons, which can be won from the bogs of the country. The Irish Peat Inquiry Committee, of which the present writer was a member, was appointed to suggest what means should be taken to ascertain the conditions under which the peat could be profitably won, prepared, and used in the most favourably situated localities. The main report of the Committee, which is contained in the publications under notice, recommended the purchase by the State of a large bog in which hand and mechanical methods of winning peat could be tried side by side. These tests would require to be continued over a long period if

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[1] "The Winning, Preparation, and Use of Peat in Ireland." Reports and other Documents. (Fuel Research Board. Department of Scientific and Industrial Research, 1921.) 3*s*.